January 1995

Brad Bradley
Office Of Superfund
Region 5
US Environ Protection Agency
77 W Jackson Blvd
Chicago, IL 60604-3511

SUBJECT: TREATING HEAVY METALS AT REMEDIATION SITES

Dear Brad Bradley:

RMT is announcing a program to provide ready access to heavy metals fixation chemistries that have been used primarily for RMT's consulting clients over the past decade. RMT has used these chemistries to treat **lead** and **cadmium** at RCRA and CERCLA sites in projects ranging up to 350,000 cubic yards. **Typical project savings** in comparison to conventional treatment methods, such as Portland cement, range from **10 to 75 percent**.

The USEPA and state regulatory agencies now recognize that it is no longer satisfactory to just "beat the TCLP test" (i.e., render the waste "nonhazardous"). Water, acid rain, and multiple elution leach tests that predict the **long-term effectiveness** of the treatment method are needed to make sure that the treated waste or soil will not affect groundwater over the years to come. RMT has been developing heavy metals fixation chemistries that meet these requirements for more than ten years.

In our work for hundreds of metals industries clients since the RCRA regulations first became effective in 1980, we've continually heard clients say:

> ***"We don't want to have to treat the waste over again five or ten years from now."***
>
> ***"We want to keep the treated waste on-site if at all possible."***
>
> ***"We've got to cut costs so we can use the capital for production improvements."***

In meeting those challenges, RMT has developed some of the most important fixation chemistries for lead and cadmium known today. **We pioneered and refined chemistries that use phosphates** in treating lead and cadmium. **We discovered that elemental iron would reduce lead leaching**—and that the treatment is reversible if actions are not taken to make the fix permanent.

Over the past few years, we've seen other "proprietary" versions of basic chemistries which RMT has publicly presented nearly ten years ago. We've given dozens of talks and presented many technical papers on treatment chemistries for heavy metals—and we've patented some of the most widely applicable ones. For example, the combination of most common forms of phosphates or phosphoric acid with many buffering agents to treat lead and cadmium are patented by RMT under **U.S. Patent Number 5,037,479**. RMT's chemistries have also been used at more that two dozen generator sites in **systems that are exempt from RCRA permitting because they eliminate the generation of hazardous wastes**.

Pb Cd Cr As Zn Cu

RMT, INC.

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608/831-4444 - 608/831-3334 FAX

At the suggestion of several clients, RMT has decided to offer ready access to these metals treatment technologies throughout the United States. As one client said *"Lead is the PCB of the 90's. RMT is the original inventor and owner of some of the most important metals treatment technologies out there, and people appreciate the value of the original. Industries with heavy-metals problems need better solutions now. Get out there and help!"*

RMT is ready and eager to help with new ideas, a record of success, and a commitment to serving the metals industry.

We'll be sending you updates on key technical and regulatory issues involving metals treatment. **If you want to talk to someone in RMT's Metals Treatment Technology Program, call any of the numbers listed in the enclosed brochure, or use the fax sheet to request more information.**

Sincerely,

William A. Stephens

William A. Stephens, P.E.
Metals Treatment Program Manager

PHONE: (608) 831-4444	**FAX YOUR REPLY**	FAX: (608) 831-3334

CORRECT ANY INFORMATION BELOW AND RETURN TO:

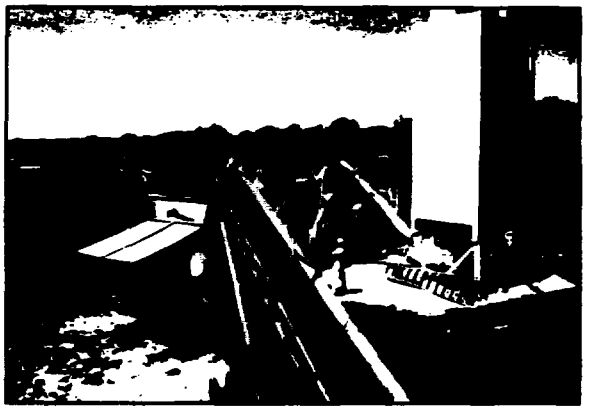
RMT METALS TREATMENT TEAM

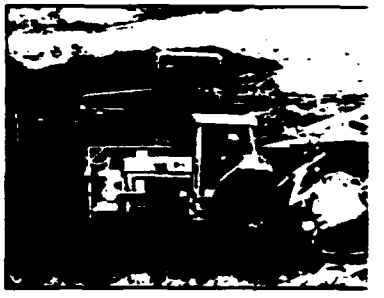
From:
Brad Bradley
Office Of Superfund
Region 5
US Environ Protection Agency
77 W Jackson Blvd
Chicago, IL 60604-3511

___ **Please contact us about treatment of:**
waste type/source:_____
metals present:_____

___ **Your phone number ( ) _____**

RMT Metals Remediation Technologies



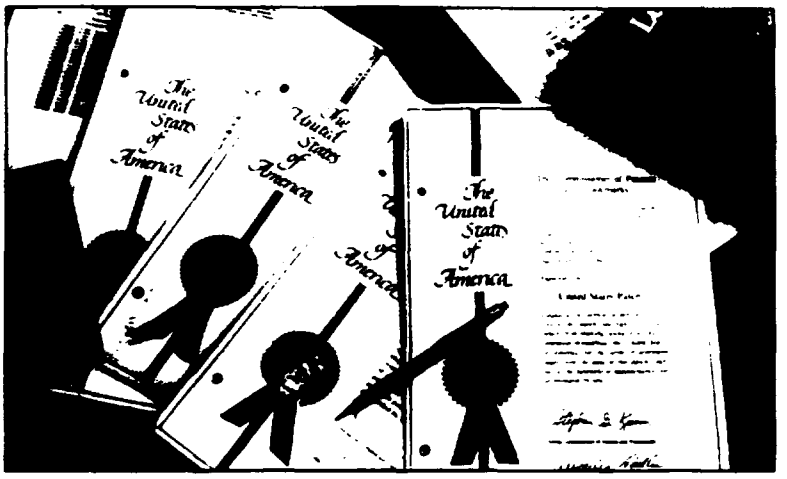


Metals Treatment Technology Benefits

- Treatment for lead, cadmium, chromium, arsenic, copper, and zinc
- Well suited to a wide range of wastes, soils, and contaminated debris
- Total project cost reductions of up to 75 percent
- Environmentally superior to lime, Portland cement, and cement kiln dust for many applications
- Field proven in dozens of applications
- Approved by state and federal regulatory agencies
- Eliminates the need for off-site disposal

Executive Summary

RMT has been developing treatment chemistries for metals-bearing waste since the early 1980's. Many RMT clients have needed treatment methods that would be effective in rendering their wastes nonhazardous and would also be **environmentally sound, permanent, and cost effective.** To meet these needs, RMT has developed treatment chemistries that cause chemical changes and render the metals virtually insoluble — whether exposed to landfill leachate, ground water, acid rain, or ordinary precipitation.



RMT's Metals Treatment Technologies are covered by the following United States Patents: 4,889,640; 4,950,409; 5,037,479; 5,202,033.

The strength of RMT's chemical fixation methods is that they target **lead, cadmium, chromium, arsenic, copper, and zinc** for chemical control of solubility and leachability across a broad range of disposal environments. For over ten years, they have been proven on remediation projects from 1,000 to 350,000 tons.

RMT's metals treatment processes (covered by a number of linked patents) avoid the shortcomings of other conventional metals treatment methods. Instead of merely attempting to control the pH in the TCLP test, RMT designs an appropriate mix of chemicals which converts the targeted heavy metals into virtually insoluble compounds. This provides a stable, long-term, environmentally sound solution.

RMT's treatment chemistries for lead, cadmium, and zinc reduce metal leaching using a two-part approach:

- ***The metals combine with an anion to create a relatively insoluble metallic salt.***
- ***A buffering agent maintains the pH at or near the minimum solubility range for the metals of concern.***

As shown in Table 1, very **low dosages of RMT chemicals** (usually **1%** to **10%** by weight) **produce dramatically reduced bulking** as compared to more traditional lime-based solidification/stabilization technologies (which usually use 10% to 100% additive by weight).

Total project cost savings are typically 10% to 75% in comparison to other technologies.

RMT has used these methods for cleanup of industrial sites, lagoons, waste piles, and landfills. The chemicals can be applied on-site using tillers, pugmills and other common types of mixing equipment. Some applications have also used chemical injection to treat the waste *in situ* (in place).

RMT's chemical treatment technologies have been repeatedly approved by the USEPA and by regulators in many states. Studies of their effectiveness have been published in technical journals and are available upon request.

This technology and engineering expertise is delivered by a strong and experienced 875-person company. RMT has a solid reputation in metals remediation and provides services through offices nationwide and internationally.

The Basics of Metals Remediation

Treatment Results Using RMT Chemical Formulations

Waste Type / Source	TCLP Leachable Lead (mg/L) Before	After	TCLP Leachable Cadmium (mg/L) Before	After	Dose Amount, Weight %
Soil ***Battery Site - Virginia***	276	<0.6	-	-	4
Soil ***Battery Site - Wisconsin***	21	<0.6	(zinc) 12.9	<0.15	2.5
Soil ***Lead Arsenate Pesticide***	370	<0.2	-	-	10
K061 - Electric Arc Furnace Dust ***Steel Mill***	66	<0.6	8.7	<0.15	10
River Bottom Sediment ***Bridge Site***	9	<0.6	-	-	1
Aluminum Oxide Dust ***Aluminum Smelter***	68	<0.1	0.25	0.049	5
Baghouse Dust ***Grey Iron Foundry***	11	<0.1	2.4	<0.006	7.5
Leaded Paint ***Steel Bridge***	10.8	<0.6	0.15	<0.15	5

Table 1

Why do it?

State and federal laws mandate the cleanup of heavy metal-bearing hazardous waste and other hazardous substances. Most notable among them are the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These laws hold corporations and governmental entities accountable for the responsible treatment and cleanup of waste sites with metals and organics contamination. Following are some examples where metals remediation is being applied:

- **Landfills, lagoons, and waste piles**
- **Soil and contaminated debris**
- **Process wastewaters and sludges**
- **Buried drums and bulk wastes**

What is it?

Metals remediation is the process of blending chemical substances with metals-bearing waste or contaminated soils or debris so that the treated material passes the Toxicity Characteristic Leaching Procedure (TCLP) criteria for nonhazardous waste and other standards that may be imposed by environmental regulations or regulatory agencies. RMT's metals treatment technologies are effective for the following metals:

- **Lead**
- **Chromium**
- **Cadmium**
- **Copper**
- **Arsenic**
- **Zinc**

Chemical fixation processes render the material nonhazardous and typically enable either on-site disposal or off-site disposal at a nonhazardous waste landfill permitted to accept the treated waste. Either option offers significant cost savings over disposal at a hazardous waste landfill. The treated material may also be suitable for recycling or constructive re-use.

Who needs it?

Industries that commonly experience a need for metals remediation include:

- **Battery manufacturers and recyclers**
- **Ceramic products manufacturers**
- **Plumbing equipment and fixture manufacturers**
- **Steel mills**
- **Ferrous and non-ferrous foundries**
- **Primary and secondary smelters**
- **Metal scrap recyclers and marketers**
- **Electronics manufacturers**
- **Electroplaters**
- **Firearm shooting ranges**
- **Commercial waste treatment facilities**
- **DOE operations waste and DOD munitions manufacturers**
- **Hazardous and hospital waste incinerators**
- **Municipal solid waste incinerators**
- **Leaded fuel manufacturers**
- **Minerals refiners and processors**

Protecting the Environment or Just "Beating the Test"?

The TCLP test was designed to predict if certain toxic constituents (lead, for example) may leach from a waste after disposal and become mobile in the environment, mainly in the ground water. Of particular concern to the USEPA is co-disposal of a lead-bearing waste at a municipal waste landfill. Once co-disposed, the lead may tend to leach due to the low pH conditions in the surrounding decomposing municipal waste. The TCLP leaching test is designed to simulate co-disposal with municipal waste.

The TCLP involves placing a small sample of a solid waste into a low pH leaching solution. After agitation of the mixture for 18 hours, the solids are then discarded and the remaining solution is compositionally analyzed for the constituents of concern, e.g., lead. If the constituent concentration in the solution is above the "hazardous limit" set by the regulations (e.g., 5.0 mg/L for lead, which is over 300 times the federal drinking water "action level" of 0.015 mg/L), then the waste is classified as "hazardous" by regulatory definition.

Keep in mind that the TCLP is a regulatory test originally designed to avoid ground water contamination at municipal solid waste landfills. Most industrial waste is not disposed of in municipal landfills, but rather in industrial landfills or monofills. Due to the neutral or slightly basic pH conditions usually found in a monofill, lead will generally not leach from the waste, even if the lead-bearing waste fails the TCLP (i.e., leaches lead above the hazardous limit).

This means that many solid wastes that fail the TCLP and are classified as "hazardous" do not actually pose a threat to ground water at their current disposal site.

Representative Hazardous Waste Leaching Test Results Using Lime-Based Treatment

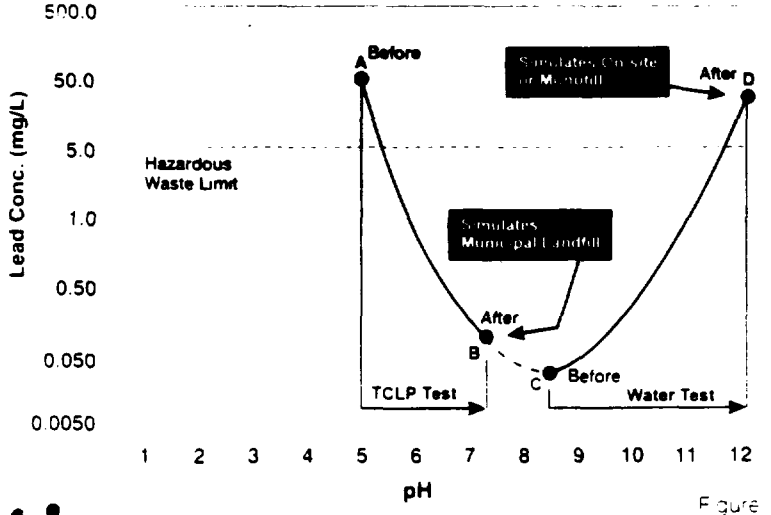


Figure 1

There are many other tests to predict leaching characteristics. Regulatory agencies and others use the "acid rain" model to predict leaching in a monofill situation. The Synthetic Precipitation Leaching Procedure (SPLP) has been designed to simulate acid rain leaching conditions at these sites. Another leaching test uses deionized water as a leaching solution. Deionized (DI) water leach tests are used to predict leaching in areas not subject to acid rain. DI water versions of TCLP, American Society for Testing and Materials (ASTM) water, and column leach tests may all be used for these purposes, depending on the situation.

Using lime-based treatment chemicals for pH control of lead, it is usually impossible to satisfy both the regulatory TCLP test and the real-life SPLP test unless the treated material is solidified as a monolithic mass.

Some treatability programs also include using actual ground water from the site. Still another leaching test, the Multiple Extraction Procedure (MEP), uses repeated leachings of the same waste solids with fresh solutions to assess how the constituents of concern may tend to leach out over time.

Many "conventional" treatments being used for lead involve mixing a high pH, lime-based chemical with the waste in question before the TCLP test is conducted. During the test, the chemical additive neutralizes the TCLP's acidic leaching solution, and the lead does not appreciably leach *in the test.*

The lime-based treatment may "beat the regulatory test," but create a real environmental problem. With the lime-based treatment, the high pH of the treatment chemical can cause lead to leach at the monofill, because lead leaches and becomes mobile in high pH as well as low pH conditions.

Figure 1 shows why this occurs. The left side of the curve shows how the leachable (and hazardous) lead levels (at point A) fall to nonhazardous levels in the TCLP test after the waste is treated with a lime-based chemical. The result is that the treatment "beats the regulatory test." However, the right side of the curve uses the SPLP test to show how the treated waste, which leached lead at very low levels before treatment, can leach very high levels of lead with the addition of lime-based treatment chemicals.

Metals Remediation Choices

Metals Remediation is the process of treating a material, e.g. soil or waste, to reduce the leaching potential of metals from the material. This treatment process can be accomplished in the following ways:

- **Solidification.** The material is mixed with a solidifying agent to form a mass with greatly reduced permeability and increased strength. The agglomerated metal/waste/cement particles have less metal surface area exposed for leaching than does the waste/metal mixture alone, so leachable metals are reduced through surface area reduction. Solidification is frequently conducted by mixing contaminated soils with Portland cement to make concrete.
- **Stabilization.** This broad category has two approaches:
  - **pH solubility control.** A very alkaline material such as lime, fly ash, Portland cement, or cement kiln dust is mixed with the material so as to neutralize the acid in the TCLP test (or in an acidic disposal environment) and produce a final pH in the test that is at or near the natural minimum solubility pH for the metal of concern.
  - **Chemical fixation.** A chemical(s) is added to the material which combines with the metals present and forms insoluble or less soluble chemical compounds. This method fixes the metals and prevents them from leaching in the leach tests and in the natural environment, over a wide range of disposal conditions.
- **Physical Separation.** This process tries to reduce the total amount of lead present by separating the lead particles from the surrounding media. This can be as simple as sorting large lead particles from the soil with a sieve. Another technique, called soil washing, separates the lead-bearing fines from the coarser soil particles in a liquid suspension. Soil washing is fairly slow, and only suitable for certain soil types.
- **Vitrification.** In this highly energy-intensive and expensive process, the lead is immobilized by encapsulating it in a glassy material made by thermally fusing the contaminated media.
- **Thermal Extraction.** Also highly energy-intensive, this process relies on the different vaporization temperatures of the materials involved to selectively drive off the metals as gases and then recapture the condensed particles as a concentrate in the emission control system. This process is the preferred method for recovery of zinc from K061 (electric arc furnace dust), and is only suitable for high-volume streams with metals content in the several-percent range.
- **Chemical Extraction.** In this process, a chemical solvent is added to solubilize the contaminant (*e.g.*, lead) from the waste material. The metal is then precipitated from the extract, treated and disposed. Removal of the solvent can be a concern.

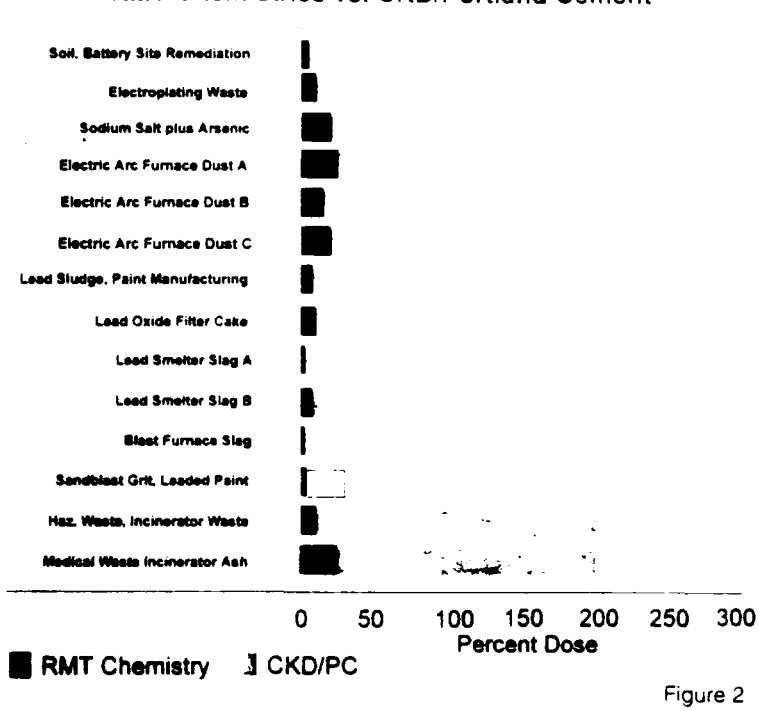


Figure 2

The RMT Approach

We produce successful metals remediation projects by making the right choices for the situation. We use combinations of methods to produce the best economics and environmental results. Over the past decade, we have found chemical fixation methods to be a critical tool for saving money while achieving more stringent performance standards.

A Point-to-Point Treatment Comparison

	RMT Chemistries	*Lime/Portland Cement/CKD*
Chemical Cost	Due to low chemical dose, total chemical expense is frequently less than lime-based treatment	Due to higher dose requirements, chemical expense may be high
Bulking Factor	Typically 0 – 10%	Typically 10 – 100%
Material Handling	Lower bulking factor decreases material handling expense, improves production, and typically shortens project duration	Higher bulking factor increases amount of material handling, decreases production which increases project duration
Transportation and Disposal	Total transportation and disposal expense decreases due to lower bulking. Less material to be transported and disposed.	Higher bulking factor drives transportation expense up due to higher volume of material to be transported.
Total Cost	Up to 75% savings over lime-based treatment is possible	Higher costs due to chemicals, material handling, transportation, and disposal expense.

Comparison to Lime/Portland Cement-Based Stabilization

Table 2 and Figure 1 describe why RMT's fixation/stabilization chemistries offer superior remediation treatment for lead and other heavy metal contamination. Note that the RMT chemistry results in very low leaching in *both* the TCLP (acid) test *and* SPLP "Acid Rain" test. Both the Lime and Portland cement treatments are able to beat the TCLP test (within narrow dosage windows), but they actually increase the lead leaching in the SPLP test.

The higher doses of Portland Cement used in this example are often sufficient to create a monolithic block which may produce environmentally sound treatment and low leaching through surface area reduction

Treatment of Lead TCLP Hazardous Wastes
Actual Test Results on a Sample of Smelter Slag

	TCLP (Acid) Leach Test		Hazardous Waste Criteria (mg/L)	SPLP Acid Rain (Water) Test	
	Lead (mg/L)	Final pH,		Lead (mg/L)	Final pH,
Untreated	600	6.0	5.0	<0.003	8.2
Lime (Calcium Hydroxide) (% by weight)					
+5%	76	6.5	5.0	290	12.2
+10%	0.2	8.6	5.0	540	12.5
+15%	6.2	10.4	5.0	510	12.5
Portland Cement (% by weight)					
+5%	450	5.3	5.0	19	11.5
+15%	<0.2	10.4	5.0	11	11.9
+25%	1.2	11.6	5.0	12	11.9
+50%	10.0	12.0	5.0	3.0	12.1
RMT Chemistry (% by weight)					
+4%	2.4	5.8	5.0	<0.003	10.6
+6%	0.4	5.5	5.0	<0.003	10.3
+8%	<0.2	5.6	5.0	<0.003	8.5

Note: All samples crushed to pass a 9.5 mm sieve per Method 1311 Toxicity Characteristic Leaching Procedure. 40 CFR. Part 261. Appendix II

Table 2

Two Remediation Project Summaries

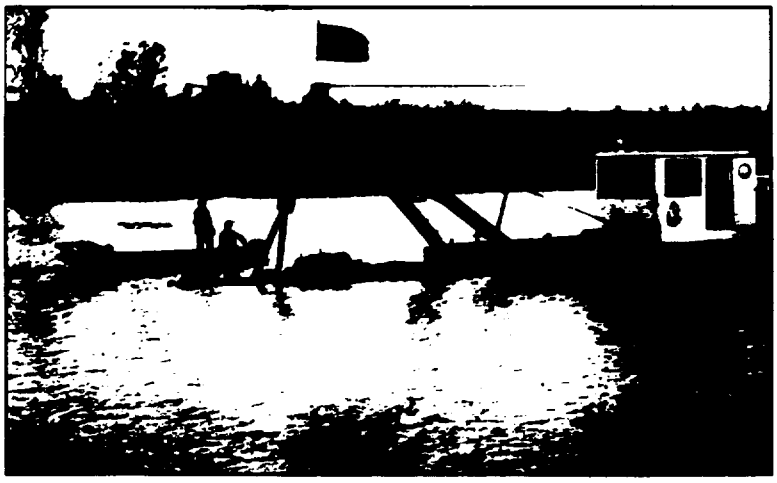
Metals Casting Industry - RCRA Lagoon and Waste Pile Closures

A large ferrous metals casting facility asked RMT to develop treatment chemistries and methods to eliminate the generation of 100,000 cubic yards of hazardous sludge, to treat 350,000 cubic yards of accumulated sludge in a RCRA storage surface impoundment, and 80,000 cubic yards of accumulated sludge in a waste pile. Large portions of the sludge had failed the TCLP criterion for lead.

RMT developed and implemented a chemical process that eliminated the generation of hazardous sludge from 20 million gallons per day of wastewater. That project took less than six months and cost less than $250,000.

RMT developed treatment chemistry for the accumulated lagoon sludge and secured USEPA and state agency approval for treatment of the sludge by chemical injection into the discharge pipe of a hydraulic dredge. The process was designed to treat 3,500 gallons per minute of waste slurry. More than 200 samples of treated sludge were taken during the remediation, with an average TCLP value of 0.51 mg/L for lead. All 200 samples were below the 5.0 mg/L hazardous waste/land ban criteria.

RMT provided construction management for the project, resulting in a total treatment project cost of less than $25 per cubic yard. This figure includes chemicals, equipment, contractor labor, and all RMT assistance. **Total cost savings were $20 million in comparison to conventional approaches. All treated wastes were disposed on-site.**



Dredging hazardous sludge from a 350,000 cubic yard lagoon.

Virginia battery site remediation in progress.

Battery Recycling Site Remediation

The C and R Battery Site in Richmond, Virginia, was remediated in 1993 using one of RMT's lead treatment technologies. RMT's treatment technology was sought by the contractor and the PRP Group as a solution that offered cost savings ***and*** better environmental results than the Portland cement-based recipe included in the Record of Decision.

The contractor excavated, stabilized, transported, and disposed of 38,000 tons of lead-contaminated clay soil. The stabilization was accomplished with a screening plant and a pugmill. The production of the treated soils averaged 1,000 tons per day. The process successfully treated materials with total lead content exceeding 12% to a TCLP characteristic level of less than 5 mg/L with a majority of the samples below detection levels for lead.

The treated materials were then placed in a Subtitle D Landfill as nonhazardous soil. The PRP Group saved several hundred thousand dollars in treating the 38,000 tons of battery recycling wastes and contaminated soils using a 6% maximum chemical dose. Support services for the project included comprehensive Quality Control and Health and Safety programs.

Let's Talk

We have scores of case studies and technical reports detailing the effectiveness of our metals treatment technologies. We'd be happy to send you further information. Please contact any of the offices listed below and ask for a professional in the Metals Treatment Technologies program.

Ann Arbor, MI
(313) 971-7080

Austin, TX
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Beaufort, SC
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